MAXIMISING CAPACITY - Critical Aspects of Planning & Managing Grid Infrastructure for High-Renewable Systems

1 | Transmission & Distribution (T&D) Upgrades now under way

Region	2025 headline projects	Why they matter for renewables
UK	*Great Grid Upgrade*: Eastern Green Link (EGL) 3–4 in Stage 2 Consultation (525 kV HVDC subsea cables, up to 680 km); EGL5 aims for 555 km, targets COD 2035 Scottish & Southern Electricity Networks ArchUp	Adds 15 GW transfer headroom from Scotland's wind & solar zones to English load centres.
	£600m National Wealth Fund loan to ScottishPower (May 2025) to accelerate seven key transmission reinforcements including EGL-1 & 4 Reuters ScottishPower	Brings forward completion by up to two years, easing north–south congestion.
Abu Dhabi	TRANSCO re-branded **TAQA Transmission**; new 400/220 kV ICAD-4 substation EPC awarded to Linxon in Feb 2025 Gulf Business Saudi Gulf Projects	Part of a 400 kV backbone that will dispatch the upcoming 5.2 GW Al Ajban solar-plus-storage complex.
	5.2 GW PV + **19 GWh BESS** mega-project announced Jan 2025 Saudi Gulf Projects	First plant in MENA sized so that storage fully absorbs solar ramp-down, slashing curtailment.
Australia	**VNI West** 500 kV double-circuit link to unlock Murray River & Western Victoria REZs, regulatory approvals progressing in 2025 Australian Energy Market Operator	Enables ~5 GW new solar wind to reach Sydney & Melbourne.
	Waratah Super Battery (SIPS): 700 MW/1.68 GWh grid-forming BESS on-track for late-2025 service Energy Corporation of New South Wales	Provides "shock-absorber" inertia so more renewables can stay online during faults.
	AEMO's draft Network Options Report highlights a 25-55% surge in overhead line costs, prompting a strategic shift toward targeted Renewable Energy Zone (REZ) lines & upgrades to support distributed energy resources (DER) – backed by NSW's AU$2.1bn Transmission Acceleration Facility. The Guardian PV Tech	Pivots spend from traditional long corridors to smarter, community-backed routes.

Sources:

- Scottish & Southern Electricity Networks
- ArchUp
- Reuters
- ScottishPower
- Gulf Business
- Saudi Gulf Projects
- Australian Energy Market Operator
- Energy Corporation of New South Wales
- The Guardian PV Tech

2 | Demand-Side Levers that unlock capacity

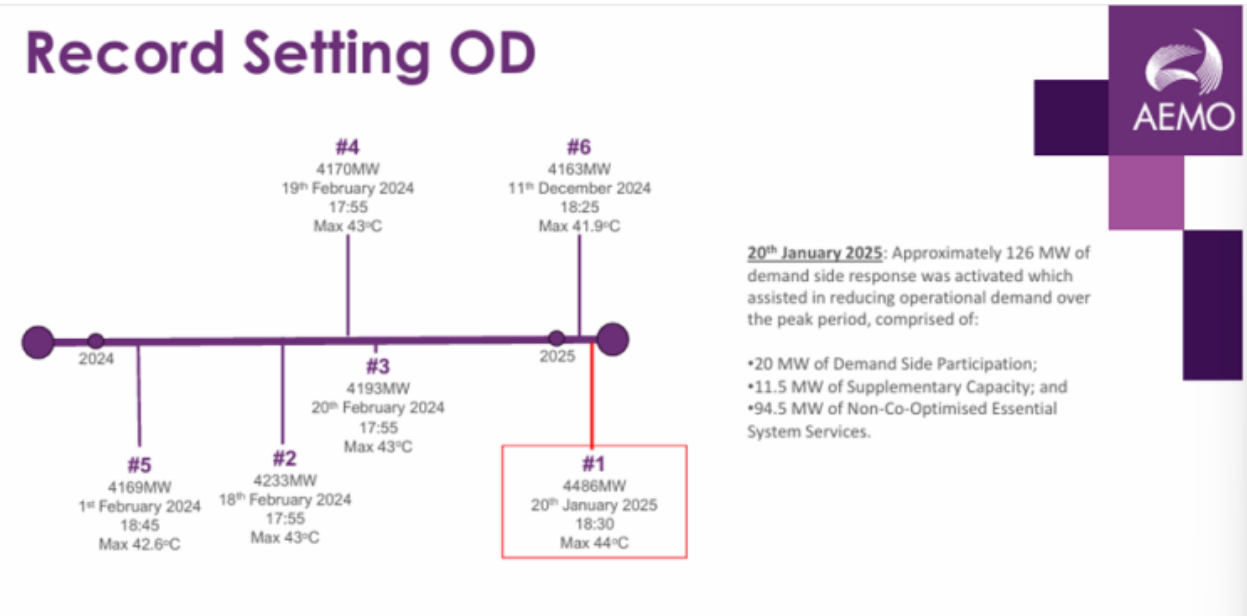
- **UK – Demand Flexibility Service (DFS)**: In winter 2022/23, 1.6 million households and businesses participated, saving over 3.3 GWh of electricity during peak times. Incentives for consumers varied, with some third-party apps offering payments ranging from **≈£2.40–£2.70 per kWh** saved during peak periods Energy UK Sunsave

Here are some options, including their potential rewards per kWh saved in the 2023/24 period:

- **Loop Energy**: This app paid around £2.50 per kWh saved (around 80% of what it received from National Grid ESO), redeemable through gift cards at the end of the 2023/24 scheme.
- **Hugo Energy**: Paying around £2.40 per kWh saved (at least 80% of what it received from National Grid ESO), the reward was redeemable via PayPal at the end of the 2023/24 scheme.
- **Equiwatt**: This app paid out the second best amount at around £2.70 per kWh saved (around 90% of what it received from National Grid ESO), redeemable through gift cards at the end of the 2023/24 scheme.
- **Ivie**: Rather than paying out a set amount, this app allows you to earn entry points for various prize draws, ranging from weekly £25 Amazon vouchers to a £1,000 cash prize (the value of these equating to around 85% of what it received from National Grid ESO).
- **uSwitch (uTrack)**: This app paid the top amount of £3 per kWh saved (100% of what it received from National Grid ESO), plus a bonus for first-time users, redeemable as a one-off payment at the end of the 2023/24 scheme.

- **Abu Dhabi – DR Pilot Phase 2**: launched May 2025, targets over **250 MW** flexible demand capacity through the participation of 30+ leading industrial and commercial entities across the emirate, in collaboration with Energy Pool as the Demand Response Aggregator UAE Department of Energy

- **Australia – Heatwave 20 Jan 2025**: During WA's 4,486 MW demand peak, AEMO activated 126 MW of demand-side response—20 MW DSP, 11.5 MW supplementary, and 94.5 MW ESS—helping avoid gas dispatch. [Australian Energy Market Operator]



These programmes flatten peaks, free transformer headroom and provide operators with rapid, software-based "virtual lines".

New laws and regulations targeting the demand side include: 1) construction regulations to increase efficiency standards in buildings, 2) utility regulations to suppress vested interests, 3) dynamic tariffs and price signals, 4) mandatory and improved metering, 5) innovation funding, 6) demand aggregation rules, 7) open data, 8) Distributed Energy Resource Management System (DERMS), and 9) smart grid orchestration (including automated demand control).

3 | Customer incentives & DSM impact on stability

Mechanism	Recent payout / effect	Grid benefit
Dynamic TOU tariffs (UK DFS supplier offers)	Households earned ~£5.50 per kWh saved during 1–2 hr DFS events (e.g. Jan 2023 via Hugo app) MoneySavingExpert	Shifts 1–2 GW from 17:00–19:00 into midday solar shoulder.
Industrial "Flex Contracts" (Abu Dhabi DR)	Participants receive capacity and performance-based payments for load reduction during peak periods. UAE Department of Energy	Makes large motor & chiller load dispatchable within 15 min.
Demand response ancillary services (DR → FCAS) (Australia)	Flexible loads delivered an **average 330 MW** of enablement in Q1-2025, covering **19 % of all contingency-raise FCAS** volume.	Provides rapid frequency support without firing up gas units, lowering FCAS costs and improving system stability.

Sources:

- Money Saving Expert
- UAE Department of Energy

4 | Energy-storage integration milestones

- **Blackhillock, Scotland** – **200 MW/400 MWh** Phase-1 live Mar 2025; will supply grid-stability services under ESO's Pathfinder scheme E&T Magazine
- **Al Ajban PV** – 1.5 GWac + 19 GWh BESS project to deliver 1 GW baseload clean power, reducing 2.4 $MtCO_2$/year; EPC awarded Jan 2025 Al Ajban | Saudi Gulf Projects | Sustainability Middle East News
- **Waratah Super Battery** – world's largest grid-forming asset; provides a 700 MW "virtual shock absorber" to release 1.5 GW head-room across the Sydney-Newcastle corridor Energy Corporation of New South Wales

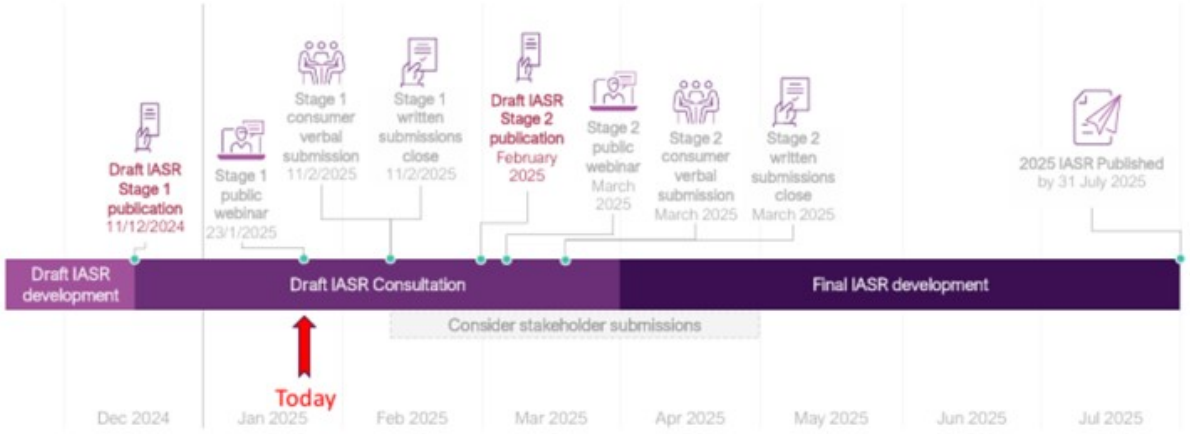
Storage soaks up surplus solar, defers line upgrades, and supplies fast frequency response - key for 100% renewables ambitions.

5 | Forecasting & digital tools for variable solar

Tool	2025 update	Accuracy gain
UK – AI now-casting (Alan Turing Institute/Open Climate Fix)	ML models improved 1 hr-ahead solar forecasts by 33% (Turing, 2019); OCF now extends this with satellite-AI National Grid Electricity System Operator	Cuts reserve requirement & congestion costs.
UK – Distribution Future Energy Scenarios 2025	First DSO to include aviation and rail electrification in DFES planning UK National Grid	Improves sub-station upgrade timing.
Australia – Draft 2025 IASR & Network Options	Public consultation on scenario inputs and network options reports closed March and June 2025, respectively. Final IASR and Network Options Reports to be published by July 2025. Australian Energy Market Operator	Feeds the 2026 Integrated System Plan capacity outlooks.

Sources:

- National Grid Electricity System Operator
- UK National Grid
- Australian Energy Market Operator



6 | Multi-stakeholder collaboration & partnerships

- **UK – Connections Reform (TMO 4+)**: NESO paused new transmission applications from 29 Jan 2025 to address a 780+ GW queue and fast-track shovel-ready renewables NESO NESO

- **UK – Offshore Transmission Network Review (OTNR)** drives joint developer/ESO design of meshed offshore grids. Gov UK
- **Abu Dhabi – TAQA restructuring**: ADDC & AADC merged into **TAQA Distribution** Jan 2025, while TRANSCO became **TAQA Transmission**—creating clear, specialised T&D entities under one holding. TAQA
- **Australia – NSW Transmission Planning Review 2025**: A state-commissioned review now coordinates Transgrid, EnergyCo, AEMO and AEMO Services, with multiple public-consultation rounds, to reform how NSW plans and funds new lines under its Electricity Infrastructure Roadmap. Energy NSW

7 | Meeting future demand – long-term resilience & security

Region	2030-plus planning signals
UK	NESO Summer Outlook 2025 expects record-low minimum demand (< 13.4 GW) due to rooftop PV; stability pathfinders & synchronous-condensers ramping up Energy Live News
Abu Dhabi	Long-duration storage (L-DES) flagged as prerequisite for >80% renewables; DEWA's 250 MW Hatta pumped-hydro to finish mid-2025 AGSI
Australia	**Battery fleet surges in Q1 2025** — AEMO's latest QED shows grid-scale battery availability **up 46 % YoY to 1,193 MW**, as Waratah (850 MW/1.68 GWh), Western Downs, Blyth and Rangebank come online; average battery output rose 86 %. aemo.com.au

Sources:

- Energy Live News
- AGSI
- AEMO

Q&A

Q1. T&D separation in the Gulf - help or hindrance?

Abu Dhabi keeps *functional* unbundling: **TAQA Transmission** owns the 400/220 kV grid, while **TAQA Distribution** handles 11–33 kV supply. Being subsidiaries of the same holding eases data-sharing and investment alignment, avoiding the split-incentive issues seen in some liberalised markets.

Q2. Sequencing grids vs renewables - who's getting it right?

The UK is synchronising by green lighting the EGL corridors alongside ScotWind projects. Abu Dhabi approved the 19 GWh BESS and ICAD-4 substation *before* Al Ajban PV breaks ground. Australia, by contrast, built 10 GW renewables ahead of transmission and is now retrofitting (e.g., Waratah battery) while rushing VNI West—highlighting the cost of lagged sequencing.

Q3. Are regulations fit for a dynamic grid?

UK connection reform and Ofgem's RIIO-ED2 rewards for DSO flexibility show progress, but developers still face multi-year queues. Abu Dhabi's mandatory DR participation rule is region leading. Australia's NEM rule changes (Wholesale Demand Response & IESS) put flexible load and storage on equal market footing, yet local planning hurdles remain.

Q4. How can utilities & regulators co-design the future grid?

Joint scenario planning (NESO + DSOs DFES, AEMO IASR) and co-funded innovation (ESO Pathfinder, TAQA-Masdar AI projects) provide blueprints. Embedding social-licence metrics, as AEMO now does - builds public trust and accelerates builds. nationalgrid.co

Q5. Can the GCC operate a 100 % renewable grid without hydropower? Key gaps?

90% looks feasible in the future but the last 10% we'll need to wait and see (currently looks difficult and expensive). Large-scale solar + multi-hour BESS (Al Ajban, 19 GWh) and emerging 250 MW pumped-hydro at Hatta cover intra-day balancing, while gas turbines equipped for green-hydrogen co-firing remain for seasonal back-up. Remaining gaps: inertia services and ultra-long-duration (>12 h) storage, which GCC utilities are now tendering (e.g., Saudi SEC 2.5 GW LDES).

1. **Build wires & flexibility together**: every £1 on HVDC or BESS can unlock ≥£2 in renewable capacity.

2. **Demand-side programmes are scaling fast**: 250 MW in Abu Dhabi, 1.6 M UK homes, providing "virtual" gigawatts.

3. **Digital twins & AI forecasting:** cut reserves and defer upgrades by double-digit percentages.

4. **Storage is no longer optional**: 400 MWh batteries (UK), 19 GWh hybrids (UAE) and grid-forming controls are now mainstream.

5. **Regulation must keep pace**: queue reform, social licence metrics and DSO incentives are the new competitive edge.

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